DOD AIR AND SPACE NATURAL ENVIRONMENT MODELING AND SIMULATION

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ABSTRACT

This paper discusses the role, responsibilities, organizational structure, current programs, and future plans of the Modeling and Simulation Executive Agent for Air and Space Natural Environment. This DoD level organization has been formed to foster interoperability and reuse of air and space natural environment models being developed for joint simulation programs, to ensure that there is no unnecessary duplication of effort in model development, to design and implement a process by which model and simulation developers and users can acquire data from a range of data providers, and to establish a center of excellence that facilitates the integration of the best available technology into DoD air and space models and simulations.

The Commander of Air Force Combat Climatology Center has been designated by the Secretary of the Air Force as the Modeling and Simulation Executive Agent for the Natural Environment. The Commander is provided operational support from the Modeling and Simulation Division of the Air Force Combat Climatology Center. This division is staffed by personnel from the Air Force, Army, and Navy in order to better coordinate the Tri-Service responsibilities of the Modeling and Simulation Executive Agent.

The Modeling and Simulation Executive Agent for Air and Space Natural Environment already has several projects underway for assessing customer requirements, defining data standards, improving data accessibility, identifying current technology capabilities, and addressing future technology shortfalls. Efforts of this organization are closely coordinated with efforts of the Terrain and Ocean Executive Agents to ensure a seamless environmental representation in simulation.

1. INTRODUCTION

The Modeling and Simulation Executive Agent (MSEA) for Air and Space Natural Environment (A&SNE) is one of three executive agents vested with oversight authority and responsibility for DoD modeling and simulation of the natural environment. The other two executive agents encompassing the natural environment are for Ocean and Terrain. These executive agents serve as the DoD components to whom the Under

Secretary of Defense has assigned responsibility and delegated authority for the development and maintenance of the modeling and simulation for the natural environment, including relevant standards and databases, used by or common to many models and simulations (DoD Plan 5000.59). Accordingly some of the primary responsibilities of the executive agents are: to promote interoperability and reuse capability for models and algorithms; to eliminate any unnecessary duplication of effort in model development; and to establish a process by which the best available models and data are readily accessible for DoD Modeling and Simulation (M&S) programs.

The air and space domain for which the MSEA is responsible includes the atmospheric, near-space, and interplanetary environments. It extends from the surface of the Earth, through the troposphere, stratosphere, upper atmosphere, radiation belts, and interplanetary medium, to the surface of the Sun. It includes the effects and impacts caused by human activities, but does not include those activities or objects causing the effects or impacts. The air and space environment affects, and is affected by, the oceans and terrain through the transfers of heat, momentum, and moisture. In order to ensure these effects are properly represented, the activities of all three environmental MSEAS are closely coordinated.

The Under Secretary of Defense for Acquisition and Technology (1996) designated the Department of the Air Force as the MSEA A&SNE. Subsequently the Secretary of the Air Force delegated this authority to the Commander of the Air Force Combat Climatology Center (AFCCC) located at Scott Air Force Base, Illinois. The present AFCCC Commander is Col Francis Routhier.

2. ORGANIZATIONAL STRUCTURE

Col Routhier, as the Commander of AFCCC, reports to the Commander of the Air Weather Service and as the MSEA for A&SNE, reports to the Director of the Defense Modeling and Simulation Office (DMSO). The AFCCC Commander must also closely coordinate with the Air Force Staff responsible for Modeling, Simulation and Analysis (XOC) which, starting in fiscal year 1998, will be providing all overhead funding for the MSEA functions. The AFCCC Commander, in the role as the MSEA, is supported by the Modeling and Simulation Division of AFCCC.

This division, which was created at the beginning of the 1996 fiscal year, consists of the following three branches: Requirements Analysis, Technology Integration, and Standardization. The Requirements Analysis Branch identifies and documents DoD M&S weather requirements, capabilities, and any resulting technology shortfalls. It is the responsibility of the Technology Integration Branch to identify technologies for solving shortfalls, to guide DoD short-term and long-term efforts for technology development and implementation, and to coordinate M&S weather technical support to all DoD M&S activities. The Standardization Branch develops and coordinates standards for weather products and services to ensure interoperability with DoD M&S systems, and guides the DoD verification and validation of weather models, modules, algorithms, and data used for joint M&S applications. The other two divisions of AFCCC, Systems and

Operations, also have expertise which the AFCCC Commander draws upon as required to assist with MSEA activities.

The Modeling and Simulation Division is currently staffed by five government personnel, four military and one civilian, and four on-site contractor personnel. All three branches of the Military are represented in the Division to better coordinate Tri-Service M&S activities. Navy Commander Timothy Cummings serves as the Division Chief. The Requirements Analysis and Standardization Branches are headed by Air Force Captains Anthony Moninski and Bruce Lambert, respectively. Air Force Major Spencer Chapman heads the Technology Integration Branch. An Army civilian, the author who is on loan from the Army Research Laboratory's Battlefield Environment Division, is assigned to the Technology Integration Branch.

3. CONCEPT OF OPERATIONS

The Concept of Operations (CONOPS) is described in detail in the MSEA A&SNE Execution Plan (DoD MSEA A&SNE, 1996). The CONOPS is focused on our customers and the means by which we can satisfy our customers' requirements with quality products and services. The CONOPS process is outlined in Figure 1.

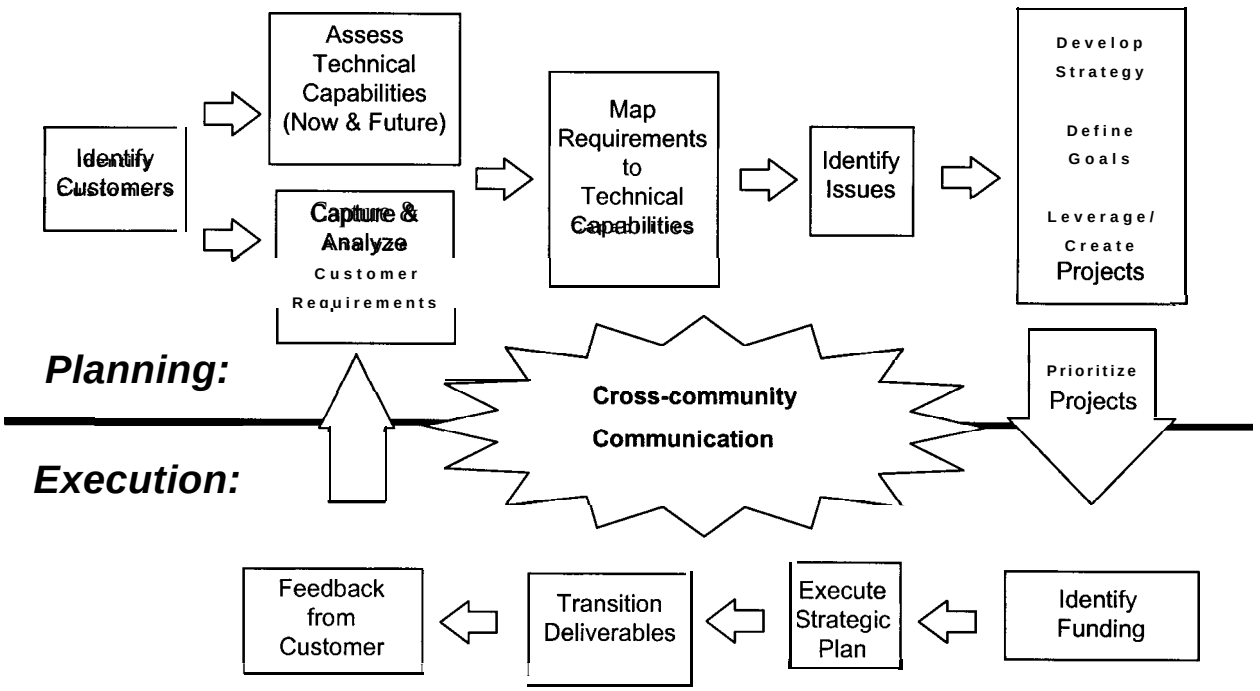

Figure 1. Diagram outlining CONOPS activities.

The two main components of the CONOPS are planning and execution. The first step for planning involves identifying customers. The custo-mers presently identified include four major joint simulation development programs and one joint aircraft development program which has a significant simulation effort planned. The four simulation

development programs are: the Joint Warfighting System (JWARS) - to be used for analysis, the Joint Simulation System (JSIMS) - to be used for training, the Joint Modeling and Simulation System (JMASS) - to be used for engineering and acquisition, and the Synthetic Theater of War (STOW) - to be used for integrating virtual and constructive simulations from geographically distributed locations in a common synthetic battlespace. The aircraft development effort we are supporting is the Joint Strike Fighter (JSF) Program. The JSF program will make extensive use of advanced modeling and simulation techniques in all phases of the aircraft's development and acquisition. Additional customers will be added as resources permit.

Once the customer has been identified, planning progresses to defining their air and space environmental requirements and documenting them in writing as well as recording them in a relational database. This relational database is also being populated with information on technical capabilities (both existing and under development) which will allow mapping between requirements and capabilities. The requirements and capabilities analysis will be conducted on a recurring basis.

In situations where a capability already exists for a specific requirement, the MSEA will assist the customer in obtaining the technology and ensuring that the capability does in fact satisfy the customer requirement. Any requirement which is not matched to a suitable capability is identified as a shortfall. A strategy and prioritization is subsequently established for addressing the shortfall.

The execution phase begins with the creation or leveraging of a project that will address the shortfall. Next a request for proposal (RFP) will be prepared for each project and interested organizations will be invited to submit a proposal. These proposals will be reviewed by the MSEA . The proposal selected by the MSEA then will be recommended to DMSO for funding. Once a proposal is approved by DMSO, the selected organization will be funded to complete the described work. Upon completion of the project, MSEA will be responsible for transferring the technology to the customer and ensuring the customer is satisfied with the product.

The CONOPS is a continuous process and customer feedback is important throughout the process.

4. PROJECTS

The projects supported by all three environmental MSEAS are grouped into the following five program focus elements: requirements and capabilities, standards, just-in-time production, dynamic representation, and access to resources. DMSO has requested that all three MSEAS group their projects into these focus areas so that it easier to coordinate the projects to ensure that a complete and seamless representation of the environment is obtained. The MSEA A&SNE has funded projects in all five program elements for fiscal year 1997.

4.1 Requirements and Capabilities

This program element includes all projects that are primarily responsible for accumulating, interpreting, and analyzing M&S developer and user requirements and the capabilities within government, industry, and academia for satisfying those requirements. The MSEA A&SNE has funded three projects under this program element.

A requirements study is underway as a continuing effort to thoroughly define customer requirements. Initial results of this effort are summarized in the Air and Space Natural Environment Baseline Requirements Assessment report (ABACUS, 1996). All the gathered information will be stored in a relational database that will be accessible over the Internet. This work is being performed by ABACUS Corporation.

A parallel capabilities study has been initiated which will identify and describe technology that has a high potential for satisfying the customer requirements. The information gathered here will be summarized in a written report and recorded in the relational database containing the requirements information. A Technical Development and Implementation Plan (TDIP) will also be generated as part of this study. The TDIP will describe the shortfalls that result from a comparison between the requirements and capabilities information and will recommend both interim and long-term solutions for the shortfalls. The Dynamics Research Corporation (DRC) is conducting this effort.

We are funding the creation of a Tri- Service Laboratory consortium as a means to utilize the talents of the Army Research Laboratory (ARL), the Naval Research Laboratory (NRL), and Phillips Laboratory (PL). The consortium will serve as a forum for blending research from all three Services to develop and optimize M&S solutions for the Joint M&S programs.

4.2 Standards

The Standards program area includes those projects that establish rules governing models, simulations, data, and metadata. These rules allow the M&S community to build to a common understanding of the environment and thereby promote maximum interoperability and reuse. We have three projects in this focus area.

A verification, validation, accreditation and certification (VVA&C) strategy is being formulated which will allow the data producer, tool developer, M&S system developer, and M&S system user/value adder to define, build, and interchange required M&S environmental domain resources. This project is being conducted both internally and in cooperation with other environmental MSEAS and DMSO supported groups.

The Synthetic Environment Data Representation Interchange Specification (SEDRIS) project is responsible for establishing a mechanism which facilitates standard

representation of and access to existing synthetic environment data, increases the utility of legacy databases, and can be easily expanded to capture future modeling investments. The mechanism is a data model which facilitates broad reuse of synthetic environments, supports interoperability of heterogeneous simulation systems, and has application across the modeling and simulation community. The Terrain MSEA is managing the SEDRIS project. The air component of SEDRIS has been contracted to TASC, Inc. NRL is assisting with the space component of SEDRIS.

A data dictionary is being prepared as part of the data representation standards for use in air and space M&S. We are leveraging the work of the Joint Meteorology /Oceanography (METOC) Data Administration Steering Committee. As one of its goals this group will establish common METOC data definitions by developing a METOC data model as an extension to the DoD Enterprise Data Model and registering the data elements in the Defense Data Dictionary System (DDDS).

4.3 **Just-in-Time Production**

Just-In-Time production projects provide the capability to generate authoritative standard data or value-added data on-demand from available data sources in time to meet warfighter pre-mission, mission planning, mission rehearsal, execution, and post-mission review needs. We are funding three projects within this program element.

The High Resolution Gridded Climatology project is developing the capability to generate hourly, annual climatology of four basic atmospheric parameters (wind, temperature, precipitation, and pressure) and several derived parameters such as visibility at 10km resolution for theater-sized regions. This project is enlisting the expertise of AFCCC, PL, Meso Inc, and Saint Louis University.

We are supporting an effort which will help to model significant environmental effects on systems. This effort leverages the ongoing Wright Laboratory Extreme and Percentile Environmental Reference Tables (ExPERT) that generates climatological datasets used to determine the environmental impact occurring during the life-cycle process of a weapon system. MSEA A&SNE funds will be used to improve ExPERT by 1) developing the capability to generate correlated climatological datasets and by 2) developing tables that show the relative weighting of the impact that various atmospheric parameters have on the particular components of a weapon system.

Our third initiative within this program element provides for the additional development of PL's Cloud Scene Generation Model (CSSM). Presently, CSSM is a empirical based model that can generate 3D grids of liquid water content, and can then translate these grids into textured polygons for visual representation of clouds. We are providing funding to provide CSSM with the a validated method to generate cloud scenes that are radiometrically correct. This is a joint effort between PL and ARL.

4.4 **Dynamic Representation**

The Dynamic Representation program element develops technologies that focus projects providing the capability for: (1) visual and/or mathematical (physics-based) interaction or events within a simulation that change (usually in real or near-real-time) what is or can happen to affect the results of the simulation or model; (2) dynamically consistent, time dependent, authoritative, environmental runtime database implementation that changes during the execution of a model or simulation. We are currently funding three initiatives as part of this program element.

PL's Geophysics Directorate is being supported to develop the capability to model space environmental effects on satellite systems. This effort involves coupling space environmental effects models with a virtual satellite simulation system. It will leverage existing capabilities provided by PL's GEOSpace and Satellite Simulation Toolkit software packages. The final product will be a simulation system capable of diagnosing and predicting how near-space environmental effects degrade systems on-board satellite platforms.

The MSEA A&SNE is providing funding support for Project Pinpoint. This project is a joint initiative between the IMINT Program Office and the National Air Intelligence Center. Its objective is to provide target scene visualization capability that will improve mission planning confidence, increase mission flexibility, and perform mission rehearsal for a broad range of imaging infrared precision strike weapon platforms.

There have been two projects funded in the past that model atmospheric effects on systems. They are the Phillips Laboratory Unified Simulator (PLEXUS) project and the U.S. Army Space and Strategic Defense Command's FAST Propagation (FASTPROP) project. Our PLEXUS initiative provides an improved weather input capability for the interfaces to a suite of transmissivity datasets and models. FASTPROP provides customers with weather effects on line of sight and other parameters needed for simulating the performance of air defense and other related systems. These projects are currently not funded by the MSEA due to budget constraints.

4.5 **Access to Resources**

Projects in the Access to Resources program element are to develop system capability needed to link metadata to the acquisition of required M&S resources. Access will be provided to all aspects of information or tools necessary to build and execute models and simulations. The data holding will be virtual (geographically distributed, available electronically, in a manner which is transparent to the customer).

Under this category of projects we have started development of a prototype Tools Catalog that will serve as the air and space environmental component of the Modeling and Simulation Repository (MSRR). MSRR is the DMSO supported master program that is envisioned as a collection of computer resources and information which will assist the M&S community in communicating and sharing information. The Tools Catalog will

provide the M&S user community with a convenient and cost effective means of locating the most suitable air and space natural environment tools (models and algorithms) available for their specific applications. It is being implemented using the Oracle relational database and will be accessible over the Internet via MSRR. The database will store sufficient metadata to properly characterize a tool to potential users. Colsa, Inc. has been contracted to develop the prototype.

5. CONCLUSION

Since the MSEA A&SNE is a new organization, our primary efforts are focused on establishing an infrastructure which will allow us to readily respond to the needs of our M&S customers. This infrastructure includes personnel, information, technology, and process. During the past 6 months four Air Force, Army, and Navy personnel have joined this organization to ensure that the interests of all the Services are represented. The efforts of the MSEA A&SNE are also being assisted by four on-site contractor personnel. We have started creating thorough knowledge bases about our customers' requirements and the capabilities available for addressing those requirements. A comparison between the requirements and capabilities will allow the identification of capability shortfalls. The latest computer and communication technology is being used to create the knowledge bases and to share the information they contain with the M&S community. Numerous procedures and standards are also being developed. Guidelines and procedures are being established for verification, validation and accreditation of models and verification, validation and certification of data used by the models. Data interface standards are also being established that will allow different simulations to exchange data.

6. REFERENCES

ABACUS, Inc., "Air & Space Natural Environment Modeling and Simulation Baseline Requirements Assessment", October 1996.

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